(54) Title: INTEGRATED SYSTEM MONITORING USE OF MATERIALS, CONTROLLING AND MONITORING DELIVERY OF MATERIALS AND PROVIDING AUTOMATED BILLING OF DELIVERED MATERIALS
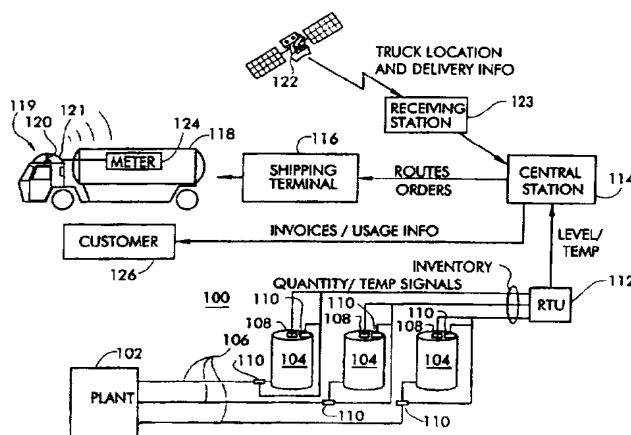
(57) Abstract

The system and method include a fleet of vehicles to provide material to a plurality of tanks at various customer locations. An inventory indicator associated with each of the tanks provides a quantity signal to the central station indicating the quantity and temperature of each of the tanks. A processor at the central station monitors the quantity signals of each of the tanks to determine past usage rates of the contents of each of the tanks. The processor projects future tank quantities based on the past usage pattern and determines possible routes for each of the vehicles to each of the tanks. The processor optimizes the routes, delivery amounts, and delivery schedule to minimize total delivered cost for the products based on the projected future tank levels and the possible routes to dispatch each of the vehicles.

INTEGRATED SYSTEM MONITORING USE OF MATERIALS, CONTROLLING AND MONITORING DELIVERY OF MATERIALS AND PROVIDING AUTOMATED BILLING OF DELIVERED MATERIALS

Background of the Invention

5   This invention generally relates to inventory management systems and methods that involve automatic product replenishment through vendor managed inventory. In particular, the invention relates to an integrated system monitoring use of materials stored in tanks,

10   controlling and monitoring delivery of materials to the tanks, and providing automated billing of delivered materials through communications between the tanks, a central station, and delivery trucks.

Inventory management is known in the art. For

15   example, the liquified gas industry has a gas delivery system which uses telemetry systems to monitor customer volume. The object of such systems is to provide substantially continuous product supply. However, such systems are not easily adapted for use in other

20   industries such as manufacturing and supply of animal feed.

Other systems define trigger points which require automatic mandatory reordering when a trigger point, such as a certain tank level, is reached. Such systems do not

25   optimize delivery routes or costs because only mandatory orders are generated. A mandatory order is an order that must be delivered to prevent a stockout whereas a discretionary order is an order that can be delivered if economical to the suppliers. Also, such systems are not

30   flexible and do not accommodate discretionary orders.

Without automated inventory management, a site manager must determine when product is needed, how much product is needed, when products should be delivered, and how the tanks should be managed. The manager telephones

35   or faxes the order to the supplier specifying delivery

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dates and amounts. The manager maintains control and accepts responsibility for down time that is a result of the site running out of a raw material. When inventory management becomes automated, that loss of control may seem alarming to both site managers and purchasing agents. However, in an automated inventory system, such as the invention, the software and equipment ensure product in the tanks at all times while allowing the customer to maintain control by establishing customized delivery parameters for each individual site.

Summary of the Invention

It is an object of this invention to provide an inventory management system that reduces raw material stock- outs, eliminates product ordering, detects line flow failure and temperature-related flow problems, improves raw material delivery service and improves worker safety at the site.

It is another object of this invention to provide an inventory management system which maintains historical usage data and is capable of forecasting future usage.

It is another object of this invention to provide an inventory management system which provides simplified billing and reduces paperwork.

It is another object of this invention to provide an inventory management system which employs dedicated delivery equipment thereby eliminating tank truck washings and the associated waste disposal typical of non-dedicated fleets.

It is another object of this invention to provide an inventory management system which reduces chances of spills, overfills and contamination during delivery and returned heels on trucks because of inaccurate order quantities.

It is another object of this invention to provide an inventory management system which eliminates the need for

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thousands of drums and/or tote bins along with the
environmental liabilities associated with container
disposal or re-use.

5   It is another object of this invention to provide a
continuous inventory monitoring facility having leak
detection capability for liquid storage facilities
thereby preparing customers for future regulatory
compliance.

         It is another object of this invention to provide a
10   system which reduces the risk of injury by eliminating
the need for employees to climb ladders, stairs, etc. to
measure inventory and also eliminates guesswork and human
errors on inventory management.

         It is another object of this invention to provide
15   continuously available inventory information regardless
of time of day or weather conditions.

         It is another object of this invention to provide a
continuous usage monitoring system resulting in accurate
usage history to reconcile against expected product usage
20   and detect costly over-addition or under-addition of raw
materials.

         It is another object of this invention to provide an
inventory management system including temperature
monitoring to reduce costly system down time in extremely
25   cold weather.

         It is another object of this invention to
economically deliver less than truckload quantities of
raw materials and to process forecasted orders to
minimize the suppliers cost of replenishing tank
30   inventory.

         In one form, the system is for use with a fleet of
vehicles to provide material to a plurality of tanks at
various customer locations. The system comprisesa
central station, an inventory indicator associated with
35   each of the tanks and providing a quantity signal to the
central station indicating the quantity in each of the

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tanks and a processor at the central station. The
processor collects and stores information from the
inventory indicators, monitors the quantity signals of
each of the tanks to determine past usage rates of the
5   contents of each of the tanks, projects future tank
quantities of each of the tanks based on the determined
past usage rates, determines possible routes for each of
the vehicles to each of the tanks, optimizes the routes,
delivery amounts, and delivery schedule for each of the
10   vehicles based on the projected future tank quantities
and the possible routes to minimize delivered cost, and
dispatches each of the vehicles in accordance with the
its optimized route and delivery schedule.

In another form, the system is for providing
15   material to a plurality of tanks at various customer
locations. The system comprises a fleet of vehicles to
provide materials to the plurality of tanks, a central
station, an inventory indicator associated with each of
the tanks and providing a quantity signal to the central
20   station indicating the quantity in each of the tanks, and
a processor at the central station. The processor is
for: collecting and storing information from the
inventory indicators; monitoring the quantity signals of
each of the tanks to determine past usage rates of the
25   contents of each of the tanks; projecting future tank
quantities of each of the tanks based on the determined
past usage rates; determining possible routes for each of
the vehicles to each of the tanks; optimizing the routes,
delivery amounts, and delivery schedule for each of the
30   vehicles based on the projected future tank quantities
and the possible routes to minimize delivered cost; and
dispatching each of the vehicles in accordance with the
its optimized route and delivery schedule.

It is another object of the system to forecast
35   demand for suppliers products to optimize production
selectively.

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Other objects and features will be in part apparent and in part pointed out hereinafter.

Brief Description of the Drawings

Figure 1 is an illustration primarily in block diagram form of one preferred embodiment of an integrated inventory management system according to the invention.

Figure 2 is a block diagram of one preferred embodiment of the central station of the integrated inventory management system according to the invention.

Figure 3 is a flow chart in block diagram form of the information used by the operator and by the dynamic consumption class assignment algorithm routine for assigning a consumption class to each tank based on the past usage of the tank.

Figure 4 is a vertical cross section of a tank illustrating various tank levels which relate to the system of the invention.

Figure 5 is a graphing illustrating an exemplary tank inventory over time of a tank which is part of the system according to the invention, showing that the system of the invention maintains the tank level above the minimum inventory level and below the capacity of the tank.

Corresponding reference characters indicate corresponding parts throughout the drawings.

Detailed Description of the Preferred Embodiments

As shown in Fig. 1, the integrated system 100 according to the invention successfully manages raw material inventory by incorporating the entire supply chain process of a plurality of locations, each having a material consuming plant 102. Generally, several tanks 104 supply liquid raw materials to each plant 102 in order to permit continuous operation. Supply lines 106 interconnect the tanks 104 supplying the plant 102 so

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that each raw material may be supplied on demand at the
appropriate level. The continuous, uninterrupted
operation of each plant 102 depends upon the inventory in
each and every tank 104 being maintained so that all
5   demands of each plant can be met. The integrated
inventory management system 100 of the invention
maintains the tank inventories 104 to permit such
continuous, uninterrupted operation.

       Each tank 104 includes a inventory measuring device
10   such as level sensor 108 such as an ultrasonic level
detector manufactured by Electronic Sensors, Inc. to
generate quantity signals indicating the inventory in
each tank 104. In addition, each tank is provided with
one or more temperature sensor 110 such as a thermocouple
15   for monitoring the temperature of the contents of each
tank or the supply lines 106. Temperature signals
generated by the temperature sensors 110 as well as the
quantity signals generated by the level sensors 108 are
provided to a remote telemetry unit (RTU) 112 which is
20   programmed to communicate information to a central
station 114 via standard voice telephone lines or other
transmission link (e.g., cellular phone; satellite). As
a result, the RTU 112 provides the central station 114
with level and temperature information. The information
25   may be automatically provided to the central station
periodically or may be obtained by polling from the
central station. For example, the central station
includes a processor (see Fig. 2) which collects and
stores information from the level sensors 108 and the
30   temperature sensors 110 by polling a tank after delivery
to confirm that a delivery has been made. The RTU may be
optionally provided with a local display so that the
customer at the site may monitor the various levels and
temperatures. When standard voice telephone lines are
35   used to interconnect the RTU 112 and the central station
114, high speed modems for data transmission may be

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employed as is well-known in the art. Where hard-wired
phone lines are impractical, wireless communication
technology in conjunction with high-speed modems may be
used to provide the level/temperature information to the
5   central station 114. At the central station, telemetry
data is collected using information systems that store,
analyze, and report inventory and usage patterns, as will
be described below in greater detail.

       Material consumption at each plant 102 is predicted
10   based on the particular site's historical consumption
pattern and available information on future changes.
Product delivery is optimally scheduled by the central
station 114 based on the site inventory and site
receiving characteristics. As a result, delivery of the
15   raw materials to the tanks 104 is customized to fit the
particular needs of the particular plant 102. The
central station 114 provides the routes and orders
information to a shipping terminal 116. A dispatcher at
the central station 114 supervises a fleet of vehicles
20   118 for delivery the various products to the tanks 104.
The orders may be mandatory orders which require delivery
by a certain date in order to a avoid a tank level from
going below a minimum level or may be discretionary
orders which may be filled at the option of the
25   dispatcher.

       The central station 114 includes prediction software
(such as Bulk Commodity Distribution provided by
Manugistics, Inc.) to accurately predict expected usage
and required delivery dates based on the unique usage
30   patterns at each particular site. In addition,
forecasted consumption levels can be adjusted by known
changes in consumption patterns. This eliminates the
possibility of emergency deliveries and stock-outs. In
general, the central station 114 is operated by the
35   material supplier who has daily access to the system data
for analysis and interpreting the results to proactively

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warn each customer of potential malfunctions that can cause production problems. The central station 114 routinely provides invoices and usage information to the customer 120.

5   Each vehicle 118 is equipped with a satellite communications system 119 including a dish 120 protected by a radiotransparent cover 121. The system 119 takes advantage of the global positioning system to indicate to a satellite system 122 (such as QTRACS offered by

10   Qualcomm, Incorporated) the position of the vehicle 118. This information is in turn relayed by the satellite 122 to a receiving station 123 which is connected (e.g., by telephone lines) to the central station 114 so that the central station 114 knows the position of each and every

15   vehicle 118.

       Each truck 118 is provided with a government certified meter 124 for accurate delivery of the right amount of product. The amount of product delivered at each location is communicated to the central station 114.

20   In one embodiment, the meter 124 is directly connected to the satellite link 120 to provide such information automatically. Alternatively, it is contemplated that the vehicle driver may be provided with a keyboard (not shown) for entering delivery information which can be

25   transmitted to the central station 114 via the satellite link-up 120 and satellite 122. It is contemplated that multiple stops by each vehicle during one route would be routinely handled and that many of, if not all, the stops may involve less than truckload quantities of liquids

30   which are delivered. The two-way communication satellite system providing information between the vehicles 118 and the central station 114 ensures prompt billing to the customer 126 of the exact amount of product delivered in addition to providing to the central station 114 timely

35   information on delivery status and truck location. In the event of weather, road, or equipment problems, the

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central station 114 is notified so that immediate action
can be taken to ensure safe, on time product delivery.

Product consumption is predicted based on a
particular site's historical consumption pattern and
available information on future changes. Product
delivery is optimally scheduled to each site based on
site inventory and site receiving characteristics
employing software such as Bulk Commodity Distribution
(BCD) available from Manugistics.

Fig. 2 is functional block diagram of the central
station 114. A processor 202 or other computer controls
the operation of the central station 114. Although it is
contemplated that the processor 202 may have an internal
clock and internal memory, the functional block diagram
illustrates a separate clock 204 and separate memories
which will be described in more detail below. The
processor 202 receives the quantity/temperature signals
generated by the monitors 108, 110 so that the processor
is provided with data indicating the level and
temperature of each of the tanks 104. This inventory
information is stored in inventory memory 206 so that the
present level and temperature of each tank is immediately
known and accessible by and through the processor 202.
In addition, as the inventory memory 206 is updated by
the processor 202, past usage information is stored in
memory 208 so that the usage pattern for each tank 104 is
monitored and available to the processor 202 for
evaluation to determine past usage rates of the contents
of each of the tanks.

Memory 210 includes future use projections which are
generated by the processor 202 by the projection
instructions 212 employing algorithms (e.g., BCD
forecasting algorithms). These instructions 212 are
software which evaluates the present inventory as
indicated by memory 206 and which evaluates the past
usage as indicated by memory 208 to project future tank

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quantities of each of the tanks based on the present
inventory and past usage rates. The instructions 212
further take into account any specific factors which have
been stored in the future use projections memory 210
5   which may affect future usage of the products within the
tanks 104. For example, such software may take in
account the following: seasonal shutdowns; periodic
maintenance; weekly demand patterns; or competitive
rotation (customer rotating supply from more than one
10   supplier). The processor 202 uses the forecasted
information to optimize total delivery cost. This is
accomplished by applying optimizing algorithms (e.g., the
BCD problem solving algorithm) which evaluates various
scenarios for routing and scheduling and determines the
15   particular scenario which would result in the lowest,
total delivered cost while maintaining all tanks
replenished with minimum inventory and meeting all other
constraints of the system. In other words, forecasted
orders are processed to minimize the cost of replenishing
20   tanks.

In order to forecast future usage, the processor 202
may employ software which classifies consumption from the
various tanks in different categories depending on usage.
For example, the invention uses a dynamic consumption
25   pattern routine to create, on demand and with varying
parameters, a consumption class designation for each
tank.

The dynamic consumption pattern routine allows
assigned classes to be generated based on actual
30   telemetry data looking backwards a preset number of days.
The daily and weekly usage is calculated and various
defaults and calculations are used to derive a
consumption class key or pattern of the form "nnnnnnn."
Each 'n' represents a digit from 0 to 4, which
35   symbolically represent the estimated normalized product
usage on the basis of a 24 hour production day by 7 days

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per week. A value of '4' signifies that regardless of how many actual hours the plant operates, their typical average usage for this day compared to an average week is roughly a normal full day of usage. Likewise, a value of

5   '1' would indicate roughly a quarter-day's production, a value of '2' would indicate roughly a half-day's production and a value of '3' indicates a three-quarter day's production.

These values are normalized so that multiple sites

10   can share the same pattern even though their absolute hours of usage may vary. The hours of operation are not nearly as important to the processor as knowing the relative usage patterns day by day and by day within a week.

15   Even though this designation can be dynamically computed, it may vary from a standard value that we wish to assign to a particular tank. For example, the dynamic computation could identify a '4344444' pattern for a site, even though they are normally in production 7 days

20   per week on a level basis. Individual spikes, or unusual circumstances, or too short of a sampling period could all account for the apparently erroneous '3' in the pattern. In the case of a high volume-customer with known production plans, it is possible to pre-code their

25   standard consumption pattern so that it overrides the dynamic pattern thereby assuring that BCD will generate a more precise demand forecast.

Due to the many variables involved, it is not possible to perfectly model consumption. However, taking

30   this approach as a first step avoids relying on plans, hearsay, or myths about customer's product usage, and instead derives the needed data based on the same data that is used to manage customer inventory -- the daily telemetry readings. For example, the following 28

35   classes may be established:

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	CONSUMPTION CLASS	CONSUMPTION PATTERN
	DEFAULT	M-F 4, SAT 0, SUN 0
	9999999	S-S 4
5	4444444	S-S 4
	4444442	S-F 4, SAT 2
	4444440	S-F 4, SAT 0
	4444421	S-T 4, FRI 2, SAT 1
	4444420	S-T 4, FRI 2, SAT 0
10	2444444	M-S 4, SUN 2
	2444442	M-F 4, SAT 2, SUN 2
	2444441	M-F 4, SAT 1, SUN 2
	2444440	M-F 4, SAT 0, SUN 2
	2444420	M-T 4, FRI 2, SAT 0, SUN 2
15	1444444	M-S 4, SUN 1
	1444442	M-F 4, SAT 2, SUN 1
	1444441	M-F 4, SAT 1, SUN 1
	1444440	M-F 4, SAT 0, SUN 1
	1444400	M-T 4, FRI 0, SAT 0, SUN 1
20	1244444	T-S 4, SUN 1, MON 2
	0444444	M-S 4, SUN 0
	0444442	M-F 4, SAT 2, SUN 0
	0444441	M-F 4, SAT 1, SUN 0
	0444440	M-F 4, SAT 0, SUN 0
25	0444420	M-T 4, FRI 2, SAT 0, SUN 0
	0444400	M-T 4, F-S 0
	0442440	M-T 4, WED 2, T-F 4, S-S 0
	0244440	T-F 4, SAT 0, SUN 0, MON 2
	0222220	M-F 2, SAT 0, SUN 0
30	0000000	UNKNOWN CONSUMPTION PATTERN

In the past, consumption classes were manually
assigned by the operator using the data illustrated in
Figure 3. However, manual assignment can become a time
consuming task in large scale systems. Therefore, it is
35   also contemplated that the system may include a dynamic
consumption class assignment (DCCA) routine as
illustrated in Figure 3 which may be executed by the
processor to assign classes automatically. The routine
would be used by the system to dynamically assign classes
40   by analyzing the historical telemetry data stored in the
past usage memory 208. The system may be programmed to
periodically reevaluate (e.g., weekly batch processing)
each consumption class of each tank and may also provide

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a printout to the operator of any consumption class changes which have been implemented.

In addition, processor 202 has access to a truck routes memory 214 which stores information indicating the various possible truck routes for each of the vehicles to the tanks of customers which are part of the system. Processor 202 executes optimizing instructions 216 (such as the BCD optimizing algorithm noted above) which evaluate the various projected usage stored in memory 210 in combination with the truck routes stored in memory 214 to provide dispatching information which minimizes total delivery cost. In particular, instructions 216 optimize the routes, delivery amounts, and delivery schedule for each of the vehicles based on the projected future tank quantities and the possible routes to minimize delivered cost. This information is stored in memory 218. This information in turn is provided to the shipping terminal 116 as routing or ordering information which is used by the dispatcher to control the vehicles 116 in accordance with the optimized route and delivery schedule. In addition, the processor is connected to the individual vehicles 118 by a satellite link 220 so that processor is aware of the truck location and delivery information for each vehicle.

As a result, the processor 202 monitors the quantity signals of each of the tanks 104 to determine past usage rates of the contents of each of the tanks, which usage rates are stored in past usage memory 208. The processor then projects future tank quantities of each of the tanks based on the determined past usage rates and stores such information in memory 210. Next, the processor optimizes the routes, delivery amounts, and delivery schedule for each of the vehicles based on the projected future tank levels and the possible routes. Finally, such optimized information is stored in the dispatch memory 218 and provided to the shipping terminal 116 for dispatching

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each of the vehicles in accordance with its optimized
route and delivery schedule. Since it is contemplated
that the system of the invention may be used with a
dedicated fleet of vehicles, the processor 202 minimizes

5   costs of delivery based on a fixed number of drivers and
equipment which comprise a set of fixed resources. By
taking into account various discretionary and mandatory
orders, as noted below, the processor selects a delivery
route and schedule which minimizes cost while maintaining

10   inventory levels. As a result, the processor 202
minimizes delivered cost based on fixed resources of
drivers and equipment while maintaining all tanks with a
minimum inventory level.

        In one preferred embodiment of the invention, the

15   satellite links 120 and 220 each include a transponder
which communicate with each other to allow the central
station 114 to monitor the position of the dispatched
vehicles 118. This link-up indicates to the vehicles
instructions from the central station and indicates to

20   the central station the position of the dispatched
vehicles. When the meter 124 is directly connected to
the satellite link 120, each of the vehicles indicates to
the central station via the satellite link the amount of
material delivered to a particular tank at a particular

25   customer location by each of the dispatched vehicles. As
a result, the processor generates billing information by
executing billing instructions 222 (such as the ROSS
Distribution Series) for generating invoices and usage
information based on the amount of material delivered to

30   a particular tank as indicated to the central station.

        The integrated software and hardware of the system
100 of the invention may interface with a client service
system that uses a central relational database so that
multiple users can have real time access to core

35   information. It is also contemplated that the projection
instructions 212 may include additional forecasting

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software (such as BCD) to predict usage trends as well as
product consumption. Also, optional routing and logistic
software (such as BCD) may be provided which incorporates
customer delivery preferences, eliminates the need for
5   manual routing and scheduling, and optimizes the
supplier's delivery equipment.

Optionally, the ultrasonic technology employed as
level sensors 108 may be configured to achieve tank
readings regardless of the tank geometry or raw material
10 characteristics. This is accomplished by appropriate
programming of the RTU.

The system may also be configured to allow customers
to specify minimum and maximum inventory levels in each
tank 104 and to allow the customer to specify acceptable
15 days and times of receiving delivery at the plant 102.
In addition, the system may adapt to the customer's daily
shifts or allow the customer to change any scheduled
plans.

Historical/forecasting software (such as BCD)
20 generally identified as projection instructions 212
offers various benefits to the customer. Site managers
can pinpoint usage levels from any day or portion of the
day, or for any raw material monitored by the system.
This data may be used for formulation verification and
25 other analysis. In addition, software which is sensitive
to historical usage detects increases or decreases from
previous patterns. As a result, customers can be
notified of these variations long before they would have
noticed an equipment problem or inventory anomaly on
30 their own.

More than simply recognizing a need for inventory
replenishment and scheduling shipment, the order
initiation software (such as BCD) which is part of the
optimizing instructions 216 plans delivery based on the
35 customer's multiple, customized specifications. In

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addition, routing and scheduling software (such as BCD)
determines the best way to route the trucks.

The billing software which is a part of billing
instructions 222 reduces effort and paperwork while
5   maintaining timely and accurate billing. Accurate
invoicing becomes even more of a challenge with multiple
deliveries or limited availability of material. However,
certified, metered trucks solve this problem when
integrated with satellite technology that transmits
10   delivery information instantaneously. Invoicing can also
be consolidated to simplify the accounting process. It
is even possible to obtain automated inventory management
services for all liquid raw materials at the plant 102,
under one umbrella, which provides one monthly invoice
15   for all liquid raw material deliveries -- a substantial
time and cost savings for purchasing and accounting
departments.

When raw material inventories are between the
maximum order level and the minimum inventory level,
20   order scheduling software can schedule delivery to ensure
customer needs are met while optimizing routing and
scheduling. Figure 4 illustrates the various tank levels
which affect the system decisions. Each tank 104 has a
capacity and the processor 202 assigns a maximum order
25   level for each tank which maximum order level is less
than the capacity of the tank. The processor 202 then
optimizes the routes, delivery amounts and delivery
schedule for a particular tank based on a delivery that
would not be made unless the tank level is below maximum
30   order level L_5 of the particular tank and the tank level
is above the minimum inventory level (see Figure 5). The
processor 202 also assigns (or defines) a heel level L_4
for each tank such that a minimum inventory level for
each tank is greater than the heel level of the tank.
35   The processor 202 optimizes the routes, delivery amounts
and delivery schedule for a particular tank based on a

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delivery schedule that prevents the tank level from being
less than the heel level of the particular tank. In
particular, the following decisions are determined:

1. The timing of a delivery is determined by: a)
forecasted usage from the tank; b) available
capacities/usages of neighboring tanks/truck availability
and utilization; c) a delivery may be made whenever tank
level is in the "delivery zone;" and d) a delivery will
be made before tank level reaches minimum inventory level
L_1.

2. The amount of the delivery is determined by: a)
available capacity of the tank (e.g., the capacity L_3
minus the ending inventory L_2); b) minimum delivery amount
for tank; c) maximum delivery amount for tank; and d)
available capacities of neighboring tanks/BTC truck
utilization.

For example, this system may be used with such
liquid feed raw materials as methionine hydroxy analogue
and ethoxyquin, and will generate inventory levels as
shown in Figure 5.

Billing instructions 222 link the system to the
accounts receivable of the supplier. This allows the
supplier to consider customer credit when making
deliveries. For example, what effect would a delivery to
a particular customer have on the credit status of the
particular customer? If a delivery would cause the
customer to exceed its credit limit, the supplier is
notified to determine how to resolve the problem.
Because of the link, the supplier has on line access to
the credit records of each client and can immediately see
future impacts of planned deliveries. Also, the system
allows the supplier to specify and access one or more
contacts via a site contact memory 224 for each location
for each customer. For example, a customer may have
separate contacts for delivery, for back-up delivery, for
purchase orders or for questions regarding usage

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deviations. This memory allows the supplier to
personally interface with the appropriate contact for
each customer. Furthermore, every contact is with a
customer recorded so that anyone who is a part of the
5   supplier's system may determine who conducted the last
communication with a contact and the reason for the
communication.

The system of the invention may also have a delivery
weight approval option. This option evaluates and keeps
10   track of order quantities, origin quantities, meter
quantities and customer weighed quantities. This system
can be used to insure that an invoice for material is
generated based on the quantity agreed upon with the
customer, eliminating costly credits, debits and rework.

15   The invention also includes a method for using a
fleet of vehicles to provide material to a plurality of
tanks at various customer locations comprising the steps
of:

collecting from an inventory indicator associated
20   with each of the tanks a quantity signal provided to a
central station indicating the quantity in each of the
tanks;

storing information from the inventory indicators;

monitoring the quantity signals of each of the tanks
25   to determine past usage rates of the contents of each of
the tanks;

projecting future tank quantities of each of the
tanks based on the determined past usage rates;

determining possible routes for each of the vehicles
30   to each of the tanks;

optimizing the routes, delivery amounts, and
delivery schedule for each of the vehicles based on the
projected future tank quantities and the possible routes
to minimize delivered cost; and

35   dispatching each of the vehicles in accordance with
the its optimized route and delivery schedule.

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In view of the above, it will be seen that the several objects of the invention are achieved and other advantageous results attained.

As various changes could be made in the above system without departing from the scope of the invention, it is intended that all matter contained in the above description and shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

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What is claimed is:

1. A system for using a fleet of vehicles to
provide material to a plurality of tanks at various
customer locations comprising:
    a central station;

5   an inventory indicator associated with each of the
tanks and providing a quantity signal to the central
station indicating the quantity in each of the tanks; and
        a processor at the central station for:
            collecting and storing information from the

10   inventory indicators;
            monitoring the quantity signals of each of the
            tanks to determine past usage rates of the
            contents of each of the tanks;
            projecting future tank quantities of each of

15   the tanks based on the determined past usage
            rates;
            determining possible routes for each of the
            vehicles to each of the tanks;
            optimizing the routes, delivery amounts, and

20   delivery schedule for each of the vehicles
            based on the projected future tank quantities
            and the possible routes to minimize delivered
            cost; and
            dispatching each of the vehicles in accordance

25   with the its optimized route and delivery
            schedule.

2. The system of claim 1 wherein each tank has a
capacity and wherein the processor assigns a maximum
order level for each tank which maximum order level is
less than the capacity of the tank and wherein the

5   processor optimizes the routes, delivery amounts and
delivery schedule for a particular tank based on a
delivery that would not be made unless the tank level is

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below maximum order level of the particular tank and the
tank level is above the minimum inventory level.

3.   The system of claim 2 wherein each tank has a
heel level and wherein the processor assigns a minimum
inventory level for each tank which minimum inventory
level is greater than the heel level of the tank and
wherein the processor optimizes the routes, delivery
amounts and delivery schedule for a particular tank based
on a delivery schedule that prevents the tank level from
being less than the heel level of the particular tank.

4.   The system of claim 1 wherein the processor
generates discretionary orders and mandatory orders and
wherein the processor optimizes the routes, delivery
amounts and delivery schedule for a particular tank based
on a delivery schedule that takes into account both
discretionary orders and mandatory orders.

5.   The system of claim 1 wherein the processor
minimizes delivered cost based on fixed resources of
drivers and equipment while maintaining all tanks with a
minimum inventory.

6.   The system of claim 1 further comprising a
satellite link including a transponder on each of the
vehicles communicating with the central station, said
satellite link monitoring the position of the dispatched
vehicles, indicating to the vehicles instructions from
the central station and indicating to the central station
the position of the dispatched vehicles.

7.   The system of claim 6 wherein each of the
dispatched vehicles indicates to the central station via
the satellite link the amount of material delivered to a
particular tank at a particular customer location and

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wherein the processor initiates the generation of billing
information provided to each customer based on the amount
of material delivered to a particular tank as indicated
to the central station.

8.   The system of claim 1 including an inventory
memory storing level data indicating the level of
material in each of the tanks, a past usage memory
storing past usage data indicating the past usage rates
of the material in each of the tanks, a future usage
memory storing future usage data indicating information
for projecting future usage of the material in each of
the tanks, and a truck route memory storing routing data
indicating the routes to be taken by the vehicles for
supplying materials to each of the tanks.

9.   The system of claim 8 including projection
instructions projecting future levels of the tanks based
on the level data, the past usage data and the future
usage data, and including optimizing algorithms selecting
the optimum routing data based on the projected future
levels.

10.   The system of claim 9 including billing
instructions executed by the processor for generating
invoicing and usage reports for each particular tank
corresponding to past usage and delivery of materials to
each particular tank.

11.   The system of claim 1 wherein the processor
assigns a consumption class to each particular tank based
on past usage of the material in each particular tank and
wherein the processor projects future tank levels based
on the consumption class.

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12. The system of claim 1 further comprising a
meter on each vehicle for measuring an amount of material
delivered to each particular tank, said meter having a
transmitter for transmitting to the central station the
amount of material delivered at each particular tank.

13. The system of claim 1 further comprising a
temperature sensor at each tank for indicating a
temperature corresponding to the temperature of the
material in the tank and a link interconnecting the
sensor and the central station and providing the
indicated temperature to the central station.

14. A system for providing material to a plurality
of tanks at various customer locations comprising:
        a fleet of vehicles to provide materials to the
plurality of tanks;
        a central station;
        an inventory indicator associated with each of the
tanks and providing a quantity signal to the central
station indicating the quantity in each of the tanks; and
        a processor at the central station for:
                collecting and storing information from the
                inventory indicators;
                monitoring the quantity signals of each of the
                tanks to determine past usage rates of the
                contents of each of the tanks;
                projecting future tank quantities of each of
                the tanks based on the determined past usage
                rates;
                determining possible routes for each of the
                vehicles to each of the tanks;
                optimizing the routes, delivery amounts, and
                delivery schedule for each of the vehicles
                based on the projected future tank quantities

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and the possible routes to minimize delivered
cost; and

25   dispatching each of the vehicles in accordance
with the its optimized route and delivery
schedule.

15.   A method for using a fleet of vehicles to
provide material to a plurality of tanks at various
customer locations comprising the steps of:

collecting from an inventory indicator associated

5   with each of the tanks a quantity signal indicating the
quantity in each of the tanks;

storing information from the inventory indicators;

monitoring the quantity signals of each of the tanks
to determine past usage rates of the contents of each of

10   the tanks;

projecting future tank quantities of each of the
tanks based on the determined past usage rates;

determining possible routes for each of the vehicles
to each of the tanks;

15   optimizing the routes, delivery amounts, and
delivery schedule for each of the vehicles based on the
projected future tank quantities and the possible routes
to minimize delivered cost; and

dispatching each of the vehicles in accordance with

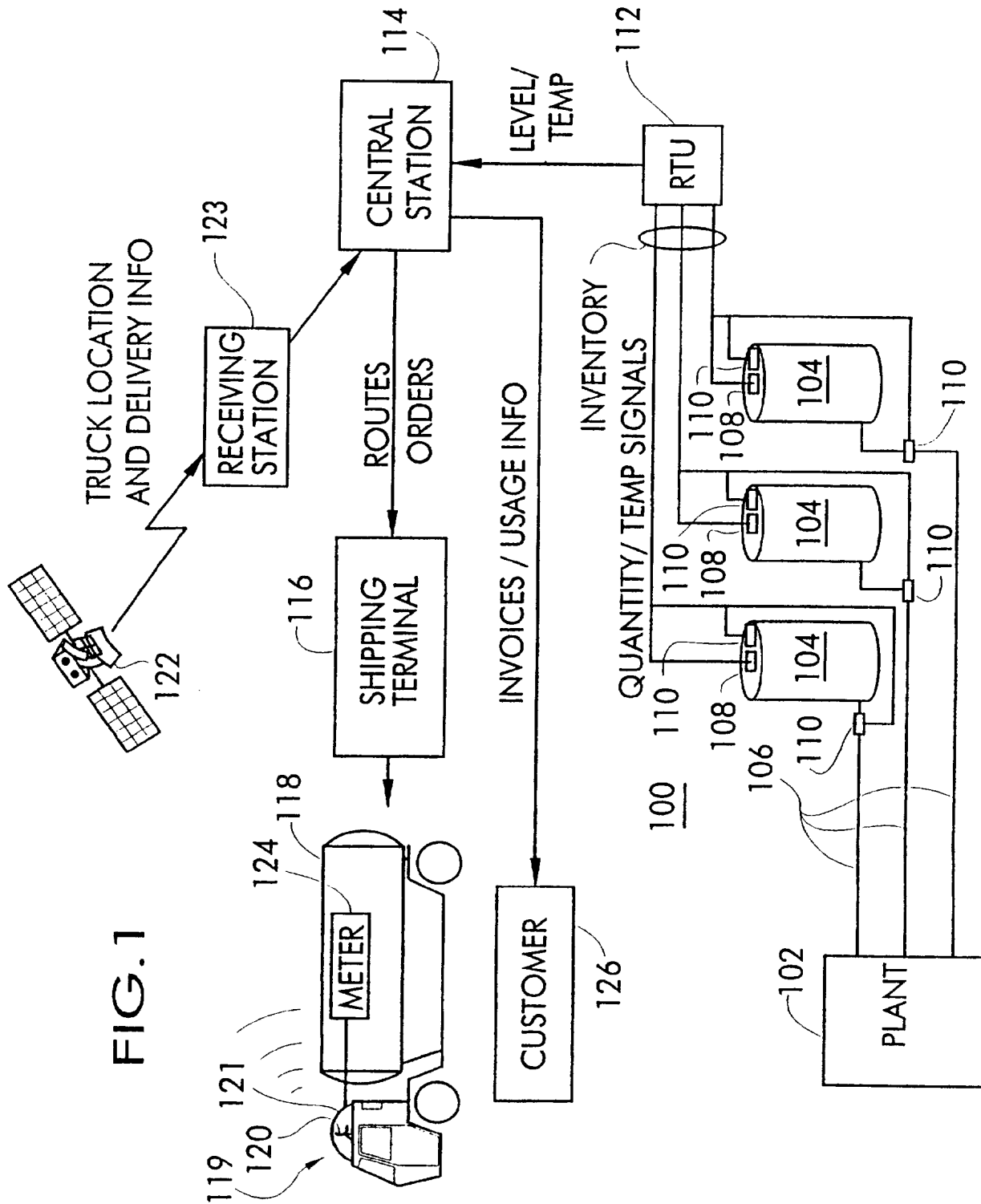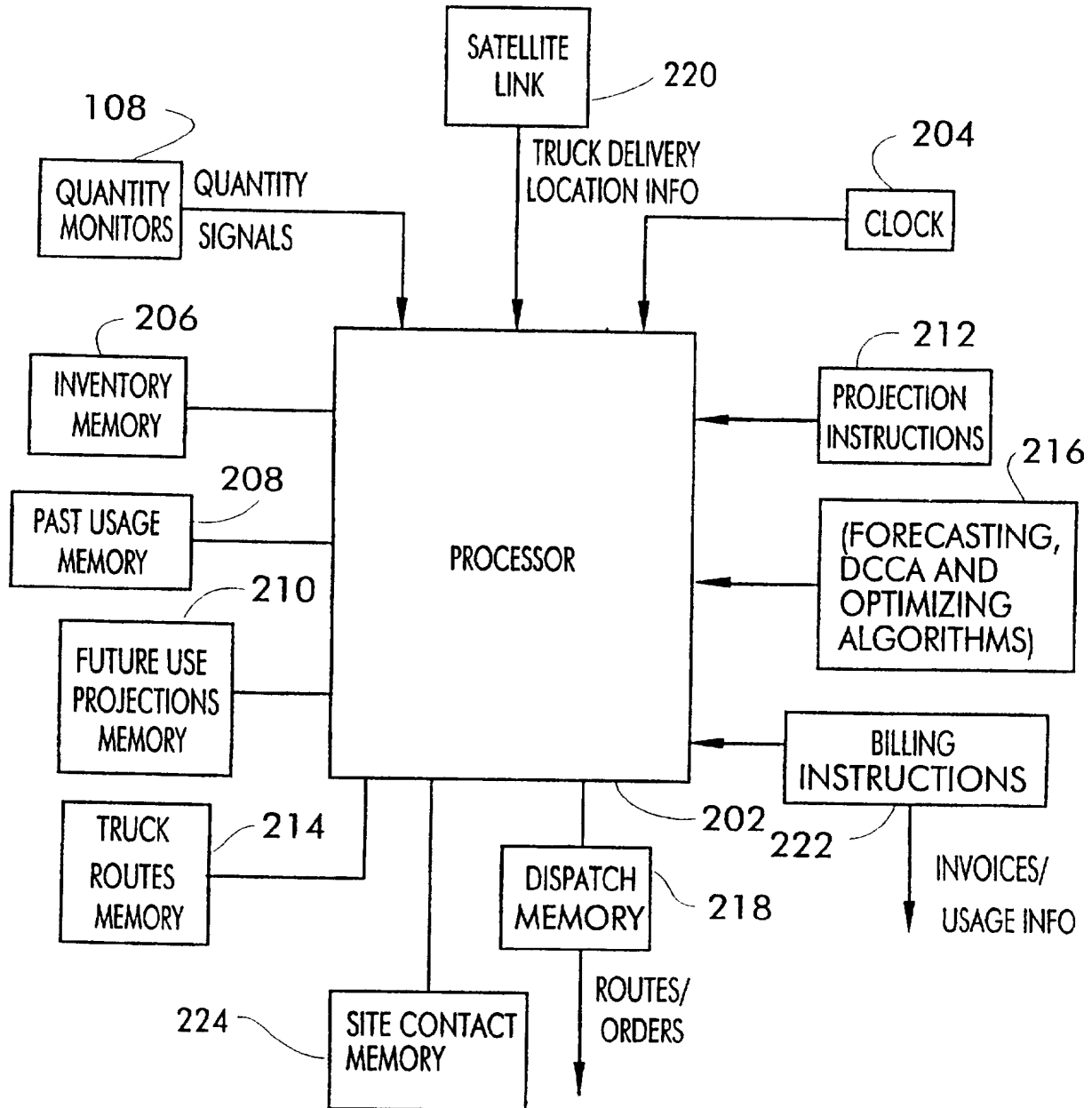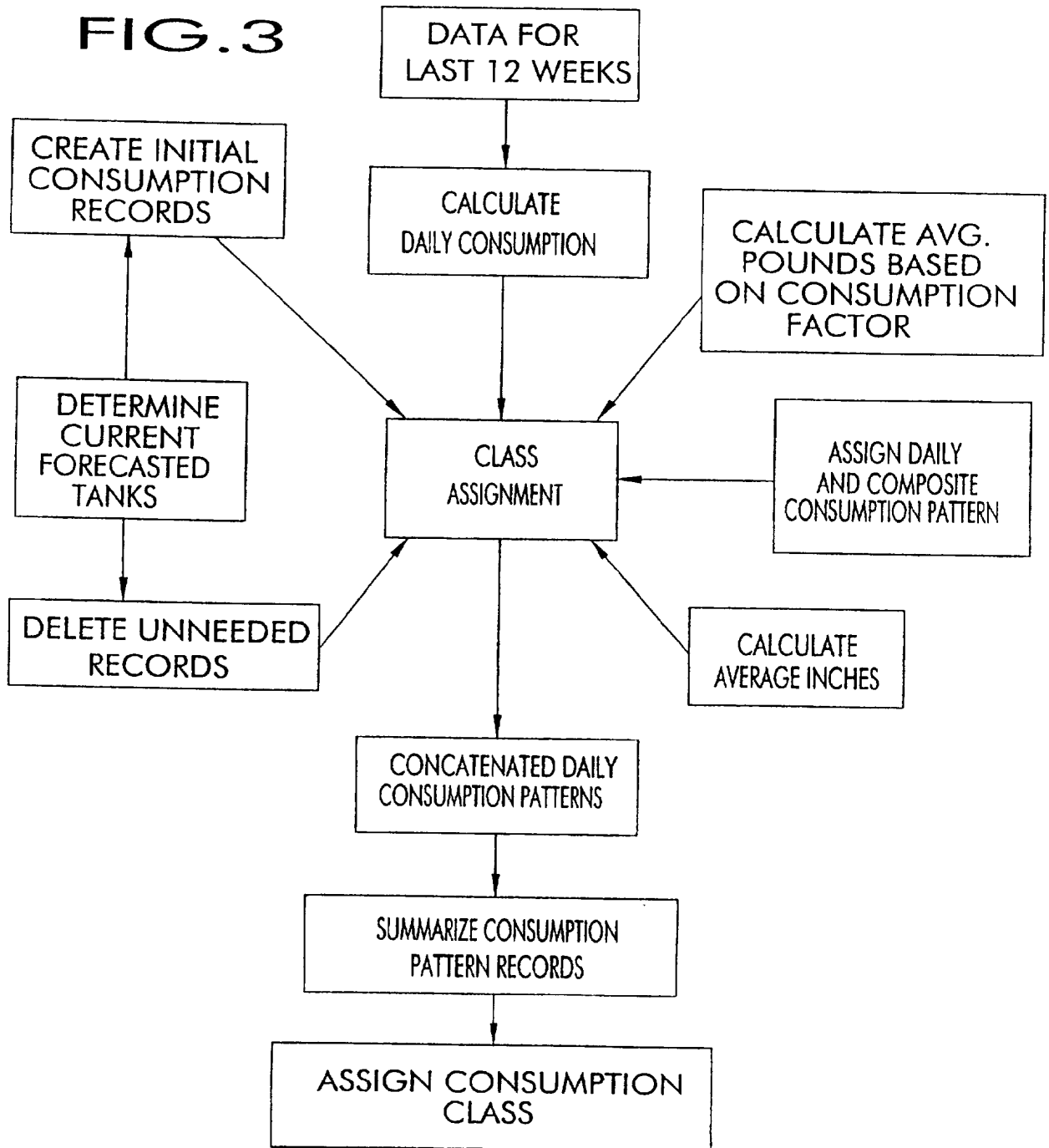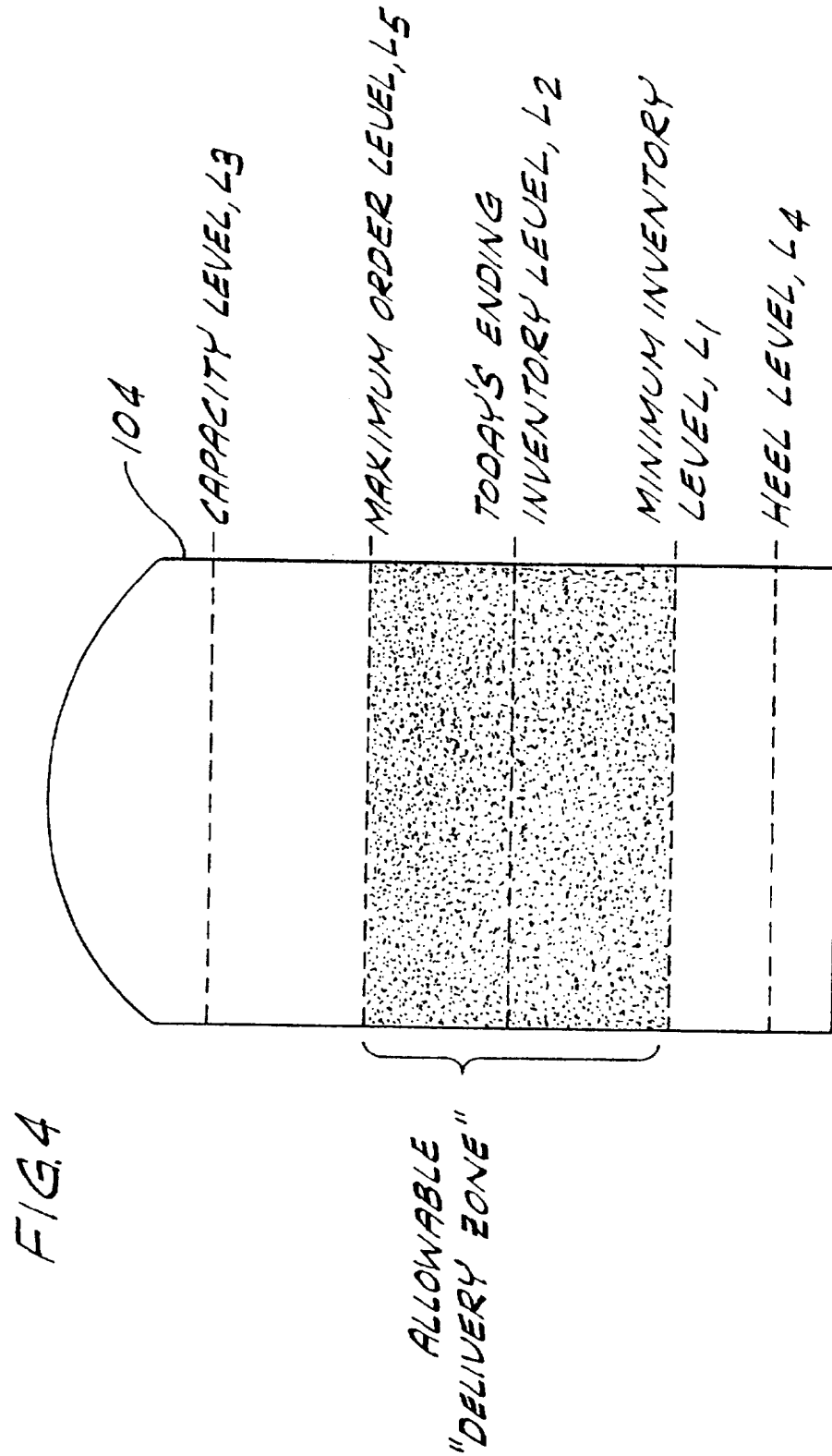20   the its optimized route and delivery schedule.

FIG.1

FIG.2

FIG.3

DATA FOR
LAST 12 WEEKS

CREATE INITIAL
CONSUMPTION
RECORDS

CALCULATE
DAILY CONSUMPTION

CALCULATE AVG.
POUNDS BASED
ON CONSUMPTION
FACTOR

DETERMINE
CURRENT
FORECASTED
TANKS

CLASS
ASSIGNMENT

ASSIGN DAILY
AND COMPOSITE
CONSUMPTION PATTERN

DELETE UNNEEDED
RECORDS

CALCULATE
AVERAGE INCHES

CONCATENATED DAILY
CONSUMPTION PATTERNS

SUMMARIZE CONSUMPTION
PATTERN RECORDS

ASSIGN CONSUMPTION
CLASS

FIG.4

FIG.5

INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6   G06F17/60   G08G1/127

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6   G06F   G08G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 154 314 A (VAN WORMER) 13 October 1992 see abstract see column 4, line 1 - line 65 ---	1-15
A	WO 90 04834 A (DIGITAL WIRELESS CORPORATION [US/US]) 3 May 1990 see abstract see page 6, line 1 - page 9, line 16 ---	1-7,15
P,A	DE 195 17 882 A (REINER BOHNEN INTERNATIONALE SPEDITION) 21 November 1996 see the whole document -----	1-15

| ☐ Further documents are listed in the continuation of box C. | | ☒ Patent family members are listed in annex. |

* Special categories of cited documents :

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

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Date of the actual completion of the international search	Date of mailing of the international search report
13 June 1997	25.06.97

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WO 9004834 A	03-05-90	US 5122959 A	16-06-92
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